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PROJECT PROPOSAL

RECHARGE AND MOVEMENT OF WATER AND WATERBORNE CONTAMINANTS
THROUGH THE ORDOVICIAN LIMESTONES WITH EFFECTS OF CONTAMINATION
ON LOCAL SURFACE WATER OF CENTRAL TENNESSEE

to be undertaken in cooperation
with the
TENNESSEE DIVISION OF WATER RESOURCES

PRELIMINARY

Prepared by
U.S. Geological Survey
Water Resources Division
Tennessee District
Nashville, Tennessee

March 1, 1982

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Water Resources Division
Tennessee District

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INTRODUCTION

Central Tennessee is underlain by Ordovician age limestones. These rocks contain and transport water in secondary openings such as joints, fractures, and bedding-plane openings enlarged by solution. The occurrence and distribution of these openings are far from being uniform because of differences in the physical character and geologic structure of formations near land surface. Consequently, the hydrologic properties of the Ordovician rocks vary from place to place and formation to formation.

PROBLEM

Grassmere Croft Farm, a 360-acre tract of land located within the City of Nashville, has been donated to the City for use as a Natural Area. The tract is bounded by industrial-commercial areas to the west, north, and east, and by a residential area to the south.

A spring fed creek dissects the property. Five springs discharge into the creek from the south with one spring forming the head of the creek near the western edge of the property. No springs were found on the north side of the creek. Each of the six springs discharges at or near the Bigby Cannon-Hermitage Formation contact.

Observations by the USGS and samples collected by the Tennessee Department of Public Health indicate that the largest spring, which forms the head of this spring fed creek, is highly contaminated with organic volatiles. One sample was reported to be "about 0.29 diesel fuel by volume." The remaining five springs do not appear to be affected by the organics. Initial sampling by the Survey of the benthic invertebrates inhabiting the springs and creek on Grassmere Croft Farm showed several cleanwater taxa present in the uncontaminated (?) springs. These invertebrates were not inhabiting the spring forming the head of the creek. After dilution by the other five uncontaminated (?) springs, the creek had not recovered at the point it leaves Grassmere Croft Farm.

Recharge to limestone aquifer results from water moving downward through the soil zone, or in some cases sinkholes, to the overburden-bedrock interface. Movement downward continues from this point through vertical cutters or joints in the rock which have been enlarged by solution. The horizontal control at Grassmere Croft appears to be the top of the Hermitage Formation, as all six springs issue at or near this horizon.

The 360-acre Grassmere Croft Farm is undisturbed as far as the land surface is concerned. However, a large tract of land, consisting of several hundred acres, bordering Grassmere Croft to the north has been mined for phosphate, been reclaimed, and is now an industrial park. A large tributary drains this tract of land and discharges into Grassmere Croft Spring Creek near the eastern edge of the property. From this observation and the fact that all the springs that discharge into Grassmere Croft Spring Creek are located on the south side of the creek, it can be assumed that the formations dip to the north and that the solution openings are controlled by the geologic structure.

Flow paths to each of the springs are separate and individual systems. A preliminary survey indicated that the conductance varied from 192 to 570 umhos at 10 sites, which include six springs. Discharge measured at the six springs ranged from 4 to 250 gallons per minute with the largest flow coming from the spring which heads up the creek that flows through the property.

4

The primary objective of this investigation is to relate the flow paths of the Central Basin aquifer system to pertinent mappable features. Emphasis will be placed on determining the area of recharge to the system and flow paths to the discharge point on Grassmere-Croft Farm. The contaminated creek will be monitored to study the recovery of Grassmere Croft Spring Creek and to determine what effects, if any, the contaminants have on the larger downstream Seven Mile Creek. Achievement of these objectives will aid in the development of criteria to guide future exploration of ground-water supplies and give insight to the impacts of pollution on both ground water and surface water draining limestone areas. *

The scope of this study will be mostly confined to the Grassmere Croft drainage area. The focus of the ground-water investigation will center on the large contaminated spring which heads up the creek. Surface-water data will be collected on the entire reach of Grassmere Croft Spring Creek plus three sites on Seven Mile Creek.

The study will be completed in three phases. During Phase I the emphasis will be placed on ground water. Test drilling will be done to locate the solution opening which transmits water to the spring. Time of travel studies within the solution opening will be done to determine flushing action within the system. Also during Phase I, background data will be collected quarterly at seven surface water sites and two springs (see attached map). Organic, inorganic, and benthic invertebrate samples will be collected, and discharge measured at each of the nine sites.

Phase II will consist of monitoring the two springs and seven surface-water sites after the contamination source is cleaned up. These sites will have discharge measured and organic, inorganic, and benthic macroinvertebrate samples collected at 2-month intervals for 1 year. At the end of each phase, the data collected will be analyzed and the sampling program revised or terminated as decided by either the USGS or the Cooperator.

Phase III will consist of monitoring the contaminated spring and site number 1 on the creek. Samples will be collected and discharge measurements will be made at quarterly intervals.

Phase I

The following work items will be completed under this phase.

- (1) Geologic Structure Maps--Structure maps and cross sections will be completed using available geologic maps.
- (2) Conceptual Model--A conceptual model will be developed using the data from the structure maps, cross sections, and current knowledge of limestone hydrology.
- (3) Remote Sensing--Files of historical aircraft photography will be searched and photographs ordered and interpreted to locate logical sources of contamination within the drainage basin of the headwater spring. Pre-development/construction photographs will be examined to locate sinkholes that could be possible sites of point-source recharge. Photographs taken during development and up to the present will be examined to locate materials-storage areas, open waste dumps, and sinks filled with trash. Pre-development photography will also be examined for natural linear features that may indicate the most likely ground-water flow paths.
- (4) Flow Paths--The most likely ground-water flow paths will be identified using the above work items 1, 2 and 3.

- (5) Test Drilling--Approximately 20 test holes will be drilled along the flow path of the contaminated spring from the spring to the logical source of the contamination. Approximately five lines of test holes will be drilled perpendicular to the flow path from the spring to the logical source of contamination. A line could require as many as five test holes to locate the contaminated solution opening.
- (6) Time of Travel Studies--Each line of test holes will be slugged with a recognizable substance, such as chloride, to determine the velocity of ground-water movement within the solution opening. The chloride slug could be picked up at the spring orifice by using a recording water-quality monitor.
- (7) Collection of Spring Water Samples--During this phase, quarterly samples will be collected at the contaminated spring and from the largest uncontaminated (?) spring during a 12-month period. The quarterly samples will be collected over a range of hydrologic events such as low-flows, flood events, and median flow. Analyses will include organics, inorganics, and benthic invertebrates. Discharge will be measured during each sampling period.
- (8) Collection of Surface-Water Samples--During Phase I, quarterly samples will be collected at four sites on Grassmere Croft Spring Creek and three sites on Seven Mile Creek. These sites will have the same data collected at the same frequency as those sites in work item 7.

At the conclusion of Phase I, an open-file interpretive report will be written describing the findings of the study to this point. At this time the decision will be made as to continuing into Phase II or terminating the project.

PHASE II

After the source of contamination and ground-water flow paths are identified, the Cooperator will undertake the responsibility of removing the material causing the contamination. Beginning with the clean-up operation and continuing for 12 months after the clean-up operation is completed, the sites sampled under Phase I will be sampled at 2-month intervals. At the conclusion of Phase II, an open-file data report will be written to include all samples collected during this phase.

The contaminated spring (spring 1) and Grassmere Croft Spring Creek (site 1) above the confluence of the first tributary will continue to be sampled at quarterly intervals to monitor improvements until the organic contaminants are down to an acceptable level.

RELATION TO 5-YEAR PLAN

Evaluating the hydrologic properties of the Central Basin aquifer system will add significantly to the areal assessment of the water resources of Tennessee. The technical information and data to be developed by this detailed study will permit the formulation, testing, modification, and quantification of pertinent conceptual models of this aquifer system. This knowledge will enhance and improve the accuracy of future regional appraisals and provide a basis for the solution of future water related problems.

RELATION TO STATE AND WRD PROGRAMS

In Tennessee, plans are developed to take advantage of contemporary opportunities to further the long-range goals of the Division in defining the water resources of the Nation, while giving due regard to the short-range needs of the State. Many communities in the State need additional water supplies; the District needs first-hand information on ground-water and surface-water potential (as related to available geologic and topographic data). This project is part of a continuing effort to adequately define the total resource.

The results of this study at the conclusion of Phase III will be presented in an interpretive report suitable for release in the WRI series. The report will summarize the hydrologic properties of this Central Basin aquifer and describe any pertinent relationships between mappable features and the occurrence of ground-water flow paths, recharge areas, areas of potential pollution, and discharge points. Surface-water interpretation will include the ability of small streams to ^a ¹ ~~d~~issiminate contamination. Results of the chemical and biological sampling in the study area will also be included in the annual Water Resource Data for Tennessee report. Open-file reports will be written for Phases I and II.

MANPOWER AND SCHEDULING

The investigation herein proposed is expected to take about 3 years to complete. It will require the assignment of one hydrologist as project chief, two junior-level assistants, none of which would require full time assignment. Additional manpower will be needed for brief periods to assist with some of the field data collection. Adequate manpower is currently available in the Tennessee District.

The total cost of this study is estimated to be \$169,000. About \$10,800 will go for test drilling services to be provided by the cooperating agency as a direct expenditure. The remaining \$158,200 represents manpower, laboratory cost, and administrative costs to the District. A breakdown of cost is shown on the cover sheet and the following page.

Prepared by: C. R. Burchett

Reviewed by: Arthur L. Putnam
District Chief

March 16, 1982

FUNDING FOR
GRASSMERE CROFT STUDY

<u>YEAR</u>	<u>USGS</u>	<u>COOPERATOR</u>	<u>TOTAL</u>
1	\$40,350.00	\$40,350.00 (includes \$10,800 direct)	\$ 80,700.00
2	24,700.00	24,700.00	49,400.00
3	<u>19,250.00</u>	<u>19,250.00</u>	<u>38,500.00</u>
TOTAL	\$84,300.00	\$84,300.00	\$169,000.00 (rounded)

Grassmere Craft Farm
Study Area

177-0145

Site # 7

Site # 6

Site # 5

Site # 3

Spring # 2

Spring # 1

Site # 4

Site # 2

Site # 1

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391

366 III SE
OAK HILL

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